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JOHN AND WILLIE LEONE FAMILY DEPARTMENT OF ENERGY AND MINERAL ENGINEERING

AN INTRA-ACTIVE FRAMEWORK FOR SYSTEMS MANAGEMENT: FACILITATING REPEATED COOPERATIVE GAMES TO CATALYZE SOLAR POLICY ADOPTION

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ABSTRACT

This thesis explores the synthesis of prior work from leading systems and management theorists to yield a cohesive framework of management design and planning using real-world example and previous empirical findings. Agential realism was used to refine systems management by aligning the emphasis of effectiveness and endogenously-defined value described by Ackoff with a Baradian intra-active methodology rooted in emergent behavior from within phenomena. Repeated games and cooperative behavior facilitation were evidenced by a system of real-world framework studied to denote their requirement within a system design to enable a group agent to manage itself effectively. Previous employment of such a framework is analyzed to demonstrate the similar catalysis of solar policy in the state of Pennsylvania. This synthesized framework of systems thinking and design could enable more solar policy in any setting to become more deeply rooted in the stakeholders it attempts to involve, thus becoming more meaningful in both its process and effect. Such a framework has the ability to shift paradigms on topics at hand, giving it the most leverage to evolve and enact effective change in the face of multiple different system-wide challenges.

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PREFACE

A glossary of specific terms is set before the paper addressing key terms used by the supporting literature. These specific meanings to enable a landscape of understanding for the reader that may find them novel, as written throughout this work. Terms used throughout all chapters of this work are given, with additional specialized terms presented and described in their respective chapters.

- **Agential realism** – theory that posits that phenomena are the basic units of existence that make up the reality with which we intra-act, highlighting that knowing and being cannot be isolated [1]
- **Beliefs** – what one feels to be real; aspect through which entities agree and make change together [2]
- **Boundary** – in an intra-active sense, something that delineates the separation of entities within a phenomenon that can be (re)configured* over time to include or exclude new entities [1], [2]
- **Endogenous** – (in contrast to exogenous) coming from within
- **Facilitation** – the guidance of communication amongst involved parties of a system that maintains the system's progress towards its goals, ensuring cohesion and participation among all
- **Graduated sanctioning** – the scaled rewarding or punishment for abiding by or deviating from rules of repeated engagement, respectively; graduated nature discourages absolute abandonment by those who are punished for deviation [3], [4]

* Barad uses the notation (re)- to denote the constant and cyclic behavior of some actions that are done intra-actively by a system (e.g. (re)iteration that denotes the constant design and improvement of iterations made).

- **Intra-action** – (in contrast to interaction) the emergence of an individual entity through bodies' mingling of their abilities to act; emergent entity defined endogenously by said mingling rather than the interaction of pre-existing bodies [1]
- **Material-discursive practices** – means by which the (re)configuration of reality is carried out by the description of a phenomenon and the tools used to observe it, highlighting an agential realist basis of the inseparability of knowing and being; e.g. intra-action [1]
- **Phenomenon** – an instance of wholeness that lacks the distinction between object and agency of observation; cannot pre-exist before the mingling of its constituent parts nor be isolated from one another [1]
- **Principles** – how one acts; aspect through which entities agree and make change together [2]
- **(Re)configuration** – the constant intra-action of defining an entity; most common use in describing the (re)configuration of boundaries amongst entities within a phenomena [1]
- **Values** – in what one invests resources; aspect through which entities agree and make change together [2]

Chapter 1

Introduction

Electric energy has grown to become an essential piece of life in the United States since the early 20th century. The demand for electricity generation has multiplied over eight times from under 500-billion kilowatt-hours (kWh) in 1950 to just over four trillion kWh today. [5] Nationally, the blend of fuels powering American homes and businesses has shifted from heavy reliance on coal, to a dominantly natural gas-powered electric system. In 2019, gas made up 38% of all electricity generated, with coal, nuclear, and renewables following with 23, 20, and 17%, respectively, with solar power accounting for 1.8% of total nationwide generation. [5] Most of the electricity generated by solar power comes from solar photovoltaics, which convert sunlight into direct electrical current. The technology has seen growth periods in the past, and is primed to see its growth increase once again as its price has reached parity with some traditional fuels like coal. [6] Adoption of solar power has been widespread, along with other renewable sources such as wind power, for its increasingly low costs, lack of reliance on a priced fuel, and production of no emissions in use. While Pennsylvania has remained slow to adopt more solar generation, there are many throughout the state attempting to change that through engagement and cooperation.

Such discourse to be presented is contingent upon the introduction of the theorists and their theories mentioned in this work in order to bring about a common ground when reading. Theorists are mentioned throughout the work, presenting the need to familiarize the reader with what aspects of each theorists' writings are being mentioned, explored, and synthesized amongst the work of others mentioned. The association of each theorists' expertise allows for the more meaningful

understanding of the paper as a whole. Dr. Russell Ackoff was a systems and management professor at the Wharton School of Business who studied the design of management frameworks to plan the operation of said system at all of its levels. Dr. Karen Barad is a professor of feminist theory at the University of California, Santa Cruz who is known for their theory of agential realism and its novel approach to ontology, ethics, and epistemology. Dr. Frey Brownson is a professor of solar power and Solar Ecology at the Pennsylvania State University who has explored the systems thinking and agential realist approaches to the emergence of solar in the state. Dr. Donella Meadows was a Macarthur Fellow, Pew Scholar in Conservation and Environment, and the founder of the Academy for Systems Change who explored systems thinking and the study of the interconnectedness of entities among a system. Dr. Elinor Ostrom was a Nobel Laureate of Economics (2009) and a professor of political economics at Indiana University and Arizona State University. Dr. Ostrom explored the field of common-pool resource management and cooperative game theory to explain behavior over the course of repeated engagements. These theorists are paramount in the synthesis presented in this paper as they each bring forth key aspects of what seem, after investigation, to be a cohesive theory of management that can be applied in any systems setting.

1. Policymaking

Inclusive and representative policy or management at any level of government or organization must come from the repeated involvement and ideation of the constituents it governs. Such involvement is rooted in effective facilitation that allows for transparent documentation and graduated sanctioning – a key to be discussed that allows for the group intention of policymakers

to stay on course during writeup. Without facilitation, the proposed bill is often placed into guideless debate that can render the original policy unrecognizable. Voices of only select, powerful groups among the policymaking system are recorded when it comes to addressing the problems that the proposed legislation hopes to manage. Such cutting of constituent voices highlights the lack of pervasive collaborative policymaking today. [7] While debate may be active during writeup, rarely does it involve affected stakeholders in a repeated fashion enough to glean any influence from them or to affirm the policy's goal as coming from within that group of stakeholders rather than from outside appropriators of the managed resource in question. Additionally, the drafting and debate of legislation can be ineffective, with core beliefs, values, and principles of the bill not being uncovered in an attempt to find common ground.

Surface level differences are found and reinforced as positions of immovable debate. The strategy of digging into the position of one's base extends the debate over legislation and lessens the chances of opposing groups coming to an agreement. [8] Such discourse over months or years saps the bill's effectiveness to address those issues. More problems form over the course of that time, the original proposers may have only focused on short-term changes, and evolutions of the same problems are to be faced all at once with ill-fitted policy at different levels of government once it is finally passed. [7] It is paramount policymaking is managed in a facilitated manner that emphasizes underlying interests and the inclusion of stakeholders from different levels of power and interest groups to enact effective policy.

2. Solar Policy in Pennsylvania

Compared to other northeastern states, Pennsylvania remains one of the least apt to see solar power grow. States like New Jersey and Maryland are seeing rapid growth in their total installed solar capacity as well as their solar policies aiding its growth, with some adding in one year what Pennsylvania has installed up to 2018. Such a low benchmark is apt, however, since the state's requirement of only 0.5% solar capacity by 2020, detailed in Table 1 below, has been the same since 2004.

Table 1: Solar requirements of surrounding states. Pennsylvania (in italics) remains one of the states with the lowest AEPS in the region. [9]

Peak Solar Share	Year	State
5.1%	2021	New Jersey
5.0%	2032	District of Columbia
3.5%	2025	Delaware
2.5%	2020	Maryland
0.5%	*2020*	*Pennsylvania*
0.5%	2027	Ohio

However, the Commonwealth remains the largest exporter of energy in the country, solar has seen little improvement since the turn of the century. [9], [10] Pennsylvania's prominence in the energy realm comes from its abundance of carbon-based fuels, namely coal and natural gas. In the early 2000's, solar's perceptions ameliorated with turns towards more favorable policy and public view. This "Energy Constraint Response", termed by Brownson, was shifted to favor natural gas soon after due to the fracking boom later in the decade. [11] Historically, Pennsylvania has seen, for the most part, level supply of a cheap traditional fuel source, allowing for the labelling of solar as insufficient. Brownson hypothesizes of an Energy Constraint Response that describes this phenomena, in which during the shift towards fuels being more "accessible, unconstrained, and

hence inexpensive, while being perceived as a necessity, light-induced energy conversion is not seen as an alternative." [11] It has been shown that the Pennsylvanian grid can handle up to 30% of its electricity coming from wind and solar, and that less than half of the abandoned state mine lands could be used to reach the grid scale requirements for scenarios reaching 10% solar carve-outs. [9] This displays the Energy Constraint Response's ability to reinforce the perceived insufficiency of solar power in a state of longstanding traditional fuel dominance. While there has been an uptick in the number of proposed policies dealing with solar in the past decade, very few have taken root and even less have rounded up the widespread support needed to become law. [12]

3. Facilitation and Agreement

In the context of policymaking, facilitation could be a powerful means to improve the overall process of discussing and enacting a law. In facilitation settings, an underlying practice to have stakeholders form agreed upon goals is to focus on underlying interests rather than the stances taken by different stakeholders. This allows for the stakeholders' beliefs, values, and principles to come to light, and allow all involved to try to find common ground. [8] Negotiations often collapse or end in ineffective compromise because of the judgement of surface level positions when they could lead to mutual gain if discussions about possible common links were discussed. Additionally, negotiations lose any headway before discussion begins because parties refuse to distance the people from the problem at hand - they lack trust with each other simply because of possible history between stakeholders or self-identification of certain members. [8]

Facilitators must come to the table knowing that the other "side" is made up of people that may hold similar ideals but have different methodologies of getting there. Facilitation itself should

not be thought of as an oppositional confrontation but as an intra-action within a team or group where mutual gain can be had. Both sides are part of the facilitation phenomenon occurring between them, and, with their discourse over the topic at hand, they (re)configure boundaries of what matters, and is excluded from mattering between the two in search of mutual benefit. That mutual gain, write Fisher and Ury, should be set and scrutinized objectively in such a way to set up achievable and agreeable system goals. [8] This design of criteria that is to be met throughout the negotiation and throughout its results allows for the system to correct itself with sanctioning if necessary instead of diving into the system without any sort of design to follow.

Chapter 2

Tools to Understand a System

Specialized vernaculars of separate theorists used in describing the management systems to be designed and theorized must first be understood in order for understanding of them to materialize uniformly. Systems thinking, dealing with components' entanglement within a system of others and that system's place amongst other systems, and joint action catalysis, dealing with the materialization of cohesive stakeholder action, covers a wide breadth of study that seems to resonate with one another in different "languages". These languages all carry the same core message, but also come with small compensations and addendums to fill out what may be missing from others' contributions. As a whole, this collection of theory can act as an effective and nearly complete understanding of, to put it basically, getting a group of stakeholders together to agree upon something.

1. "Mess" Management via Design Planning

Ackoff defines a mess as a large set of entangled problems, situations in which people must make decisions under some level of uncertainty that have significant effects. [13], [14] Those decisions can be made efficiently using the least amount of resources (e.g., time, money) or effectively using a system of weighing the outcomes of such efficiency. [15] The most effective (rather than efficient) measure of combating these messes and their problems, he writes, comes from design that heavily incorporates planning at all levels of management and with all stakeholders present in a continuous manner done by the organization being managed, not to or for it. [13], [16] Ackoff defines efficiency as either the probability to achieve a goal in a set environment or the ability to

do so with the least amount of resources, but defines effectiveness as "efficiency weighted by the value of its product". [14], [15] The value of the product of efficiency is endogenously – from within the system – determined, and, thus, the effectiveness of something is rooted in the system it serves. It is within said continuous framework of communication and management that trust and reciprocity between stakeholders are built, without which no single stakeholder can be held accountable or relied upon to carry out certain tasks or agree and contribute to the final policy being discussed. [3] In this context policymaking is a mess, as Ackoff would define it, and requires a set of management and communication methods to facilitate an initially desired outcome.

From the conception of any policy, a mess begins, and thus its management must soon follow for any semblance of the original policy's goal to materialize – policymaking is a mess itself. There exists the constant management of interests, costs, resources, timescales, and risks that all factor into each other's solutions towards the policy's original goal. [7] The recognition of policymaking as such points to system design as a means to consider the policy at hand as a system of problems that cannot be observed independent of each other and that, Barad writes, (re)configure boundaries amongst themselves. The design of a management network to handle a mess must be one that addresses the mess as such. While some individual problems may be identified and worked within the mess, the overall system of problems is never solved, rather managed - as long as the goal remains, so too does the mess. Additionally, while the mess exists, so too does the continual process of considering what the policy's goal involves. Barad writes that components of a system are constantly being (re)defined and brought in, out of, and excluded from mattering, (re)enforcing the need to look back at the system's goal and its evolution to design a proper management system. [1]

Ostrom empirically finds that the design employing continuous and repeated planning, discussion, and graduated sanctioning allows for a more optimal management solution to be found. Such a solution is greater than the summed individual efforts of stakeholders managing the mess separately and done out of a noncooperative view of the mess. [3], [17] Repeated and facilitated discussion of the plan and its overall goal allows for all stakeholders to bring forth beliefs, values, and principles on which common ground is found, building trust and reciprocity in an otherwise disparate group. Beliefs, values, and principles are categorized as what one knows as reality, what one invests in with resources, and how one acts, respectively, while trust and reciprocity are how one comes to believe an investment in a relation with another is deemed safe and the belief that the other would also invest in said relation. [2], [3] Ackoff states that an eclectic team must be present for the design of a management system, and Ostrom adds to that the requirement of repeated and trusting discussion to achieve optimal status.

2. Agential Realism and Phenomena in Systems Practices

Barad defines agential realism, an integrative theory of becoming, of ethics, and of knowing, called an onto-ethico-epistemology, which posits that the basic units of existence are phenomena – rather than things. They are the instances of wholeness (lacking distinction between object and agency of observation), which comes from the "inseparability of intra-acting agencies" enacted through boundary-making within phenomena. [1] They emerge from specific configurations of boundary-making practices – there are no pre-existing and separate entities. Barad defines intra-action as the mutual constitution of entangled agencies – the inseparability of components' abilities to act as they are constantly doing so in an entangled way. [1] Intra-action is a material discursive practice

in that it allows for the system to define what matters and create the boundary around that which matters in a determinate manner, while indeterminately excluding what doesn't. In this context, policymaking is intra-action as the legislators proposing a bill are inseparable from the subject about which they are legislating (Barad gives an example that scientists cannot be separated from the politics of science when studying it). [1] Intra-actions as material discursive practices are performative in that they act upon the things being observed, thus entangling actor and agency of observation as a phenomenon without distinction between the two – an entangled system that materializes amongst a setting of other systems. Policymaking in itself is boundary-making – it decides what matters and allows for the definition of what can be brought into mattering from exclusion from mattering through (re)configurations of that policy over time through intentionally vague language.

That is to say, boundary-(re)configuration is an agential "cut" that takes into consideration the cut itself as much as what is being cut between mattering and exclusion. Barad opposes this impermanent agential cut of mattering and boundary-setting with a Cartesian cut that focuses solely on what is deemed in the system and what is out of it based on a finite philosophy of objects. [1] By setting up vague language in laws, policymaking cannot employ Cartesian cuts, and must not be thought of as such. In policy, stakeholders and locales (time, place, culture, nature entanglements) constantly (re)configure boundaries amongst what is currently under a policy's jurisdiction (what matters) and what may come under a certain policy's reach (what was formerly excluded from mattering). This concept is depicted in Figure 1 below, which employs the lack of a frame to depict the indeterminacy of what is excluded from mattering.

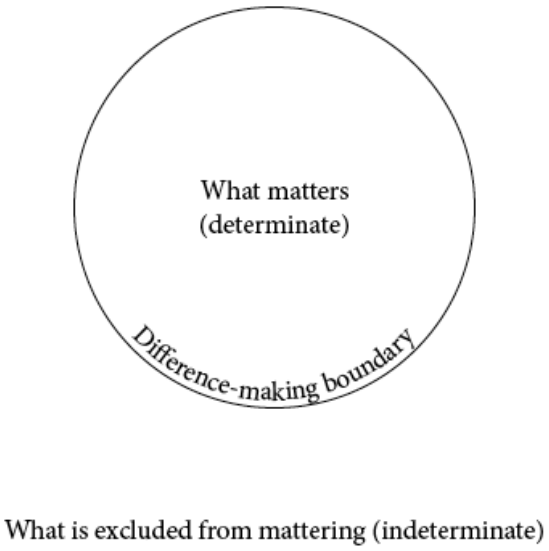

Figure 1: Baradian mattering diagram. The contents that matter are determinate and known, while that which is excluded from mattering is indeterminate and unknown but can be brought into mattering through a (re)configuration of the boundary. [1], [2]

When a system materializes and is observed, its components proceed to act within boundaries set endogenously by the system rather than by an observer, who would actually be included within those boundaries due to their observation. [1] This language is used to denote an important factor: systems are constantly (re)defining what matters (what is within those boundaries) and what is excluded from mattering (that is to say, not what does not matter, but rather not a part of what matters at that point in time). When something is excluded from mattering, its designation as such is indeterminate and can change through (re)configuring the boundaries between it and something that is determined to matter. [1] This endogenous nature of defining system goals is paramount to the work of policymaking via cooperative games and systems thinking - it allows stakeholders to (re)configure boundaries of what does, doesn't and is excluded from mattering within the system, moving from a system of disparate stakeholders simply meeting with each other towards a cohesive team of stakeholders with like beliefs, values, and principles working together.

3. Intra-active Management within Systems

Ackoff describes a management tool based on system design and the emphasis on the design's effectiveness, which align with Barad's intra-actions to refine Ackoff's definition of his overarching systems thinking framework, making it more effective. Systems thinking highlights the need to recognize not only the individual parts of a system in question (analysis), but the inter- and, and, more so, intra-action of those parts as they (re)define the system through those actions. Ackoff defines a system of problems as a mess. He states that they can only be managed if done so from the very beginning with designed management. [13], [14] This method of designing a system to help manage its inherent problems allows for the dissolution of problems rather than their solving or resolving (optimal or adequate problems approaches, respectively). [13] The system is designed such that the problem does not exist and therefore lacks the requirement of effort to be solved later in time. Hence, policymaking is system design in the sense of Ackoff's definition, but any policymaking is still a form of design and planning.

Ackoff underscores effectiveness over efficiency, where efficiency is the ability to achieve something within an environment while effectiveness is efficiency that is weighted by the *value* of its products. [15] Thus the management of a system through its design is paramount when it comes to dealing with the connected mess of problems. "It is better to do the right thing wrong than the wrong thing right" – being able to solve problems quickly isn't effective when those same problems could have been dissolved through a better plan of the system. [14] This system design, paired with "intra-activism"† – the assessment of a system and its subsequent (re)configuration

† In contrast with Ackoff's "interactivist" approach to design planning; a synthesis of vernacular that denotes the strengthening of Ackoff's definition of interactive planning with Baradian material-discursive language to increase its effectiveness.

and planning towards its end goal - is what Ackoff writes is the best way to manage a mess. [16] Intra-active planning is depicted in Figure 2 below, illustrating the connection and materialization of the components to the overall plan.

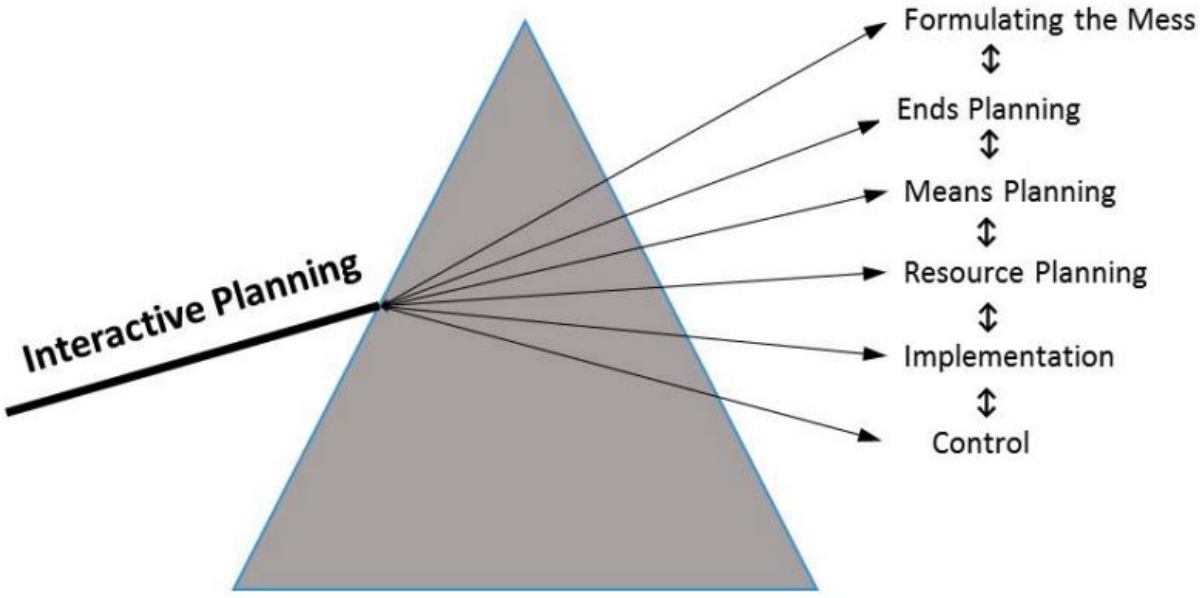

Figure 2: Prism of Interactive Planning as detailed by Ackoff. Interactive planning allows for a designed plan to disperse into multiple designed components of the plan, each able to intra-act amongst one another. [18]

Through interactive planning, the management figures the current and future states of the mess and plans ends for it to eventually reach (i.e., its goal). The strategies necessary for such ends are laid out along with their required resources. Finally, the system plan is put into place and allowed to take its course with intervention from the management coming in the form of controls and slight alterations. [16]

With the introduction of intra-activism, there exists the need to discern between interactive planning and the possible "intra-active planning." While Ackoff's definition of a management agent taking scope of a system and planning its goals, means, and resources provides sound theory, when aligned with Baradian vernacular and agential realism, such a mode of planning becomes

more robust and meaningful to the system. In an intra-active sense, the agencies of observation cannot separate themselves from the object of observation. In the synthesized intra-active planning, managers cannot separate themselves from the system they are managing. As soon as the managers begin to act within the system, they inseparably become part of it, and the phenomenon involving the two takes form. From that point, material discursive practices abound, aligning with Ackoff's steps of seeing where the system is headed and figuring out how to get to an ideal that is endogenously decided upon. In planning a goal from within a system, manager and mess become one, and both (re)configure the boundaries of mattering within that manager-mess system. This key aspect of intra-activism lets the planning of the system to be more deeply rooted in it and all involved group agents.

4. Levers Necessary for System Change

Meadows defines 12 “levers” by which large system change can occur with small interventions, with increasing leverage available to more endogenous value-based points of change. [19], [20] Those levers are detailed below in Figure 3.

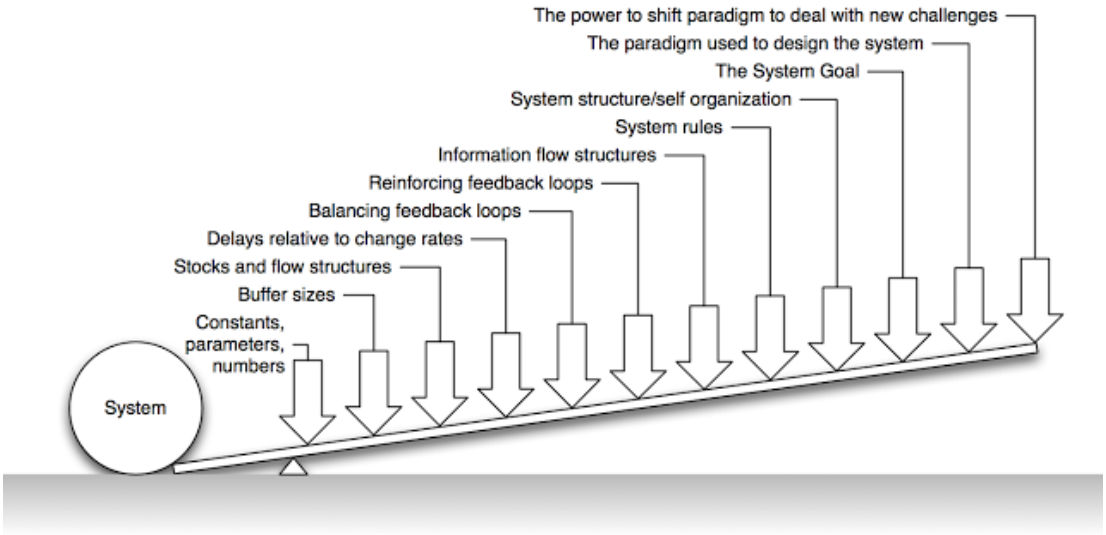

Figure 3: Meadows' levers for system change. Moving away from the system, one can increase their leverage on the system to change by shifting towards its more-value based aspects. [19], [20]

Effective policymaking requires points of change with more leverage, and many levers in Meadows’ list line up with others’ key points about how to effect change in a system: Ackoff’s design of the system and structure of a goal, Ostrom’s repeated reinforcement of system rules and flow of information, and all theorists’, including Barad’s, emphasis on endogenous goal-setting and action. Meadows writes that too often, points of change that have little leverage, like setting standards, are pushed with too much effort resulting in little change or that the right levers are pushed in the wrong direction of change. [19], [20] With respect to policymaking, trying to legislate change through the simple enactment of a government standard works much less than the ability to design a policymaking system of stakeholders that hold the power to alter their system to the legislation being proposed at the time. While a decrease in overall wasted legislative effort

results, an effective change of the system is facilitated, allowing for more underlying topics of discussion to be facilitated that focus on what drives the system that may desire a governmental standard change. Less time is wasted with pinpointing of more powerful levers required to change a system, and more effective results are produced.[19], [20]

5. Cooperative Game Theory

Ostrom writes that goods or resources are described, and thus managed, by their "rivalrousness", the ability of its use while others are already consuming it, and by their "excludability", the difficulty of excluding others from using that good. [21] A common-pool resource is one that is limited (rivalrous, e.g. land in a county) but one that does not allow for the barring of certain individuals or groups (excludable, e.g. public works) from access to said resource. [21], [22] Figure 4 below defines common-pool resources and public, club, and private goods with respect to each of these attributes.

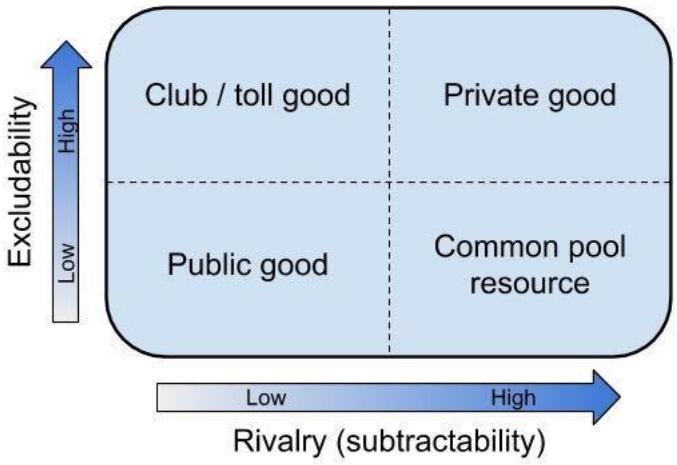

Figure 4: Goods defined by excludability and subtractability. Common-pool resources are highly rivalrous but not excludable when provisioned correctly. [17], [21]

With this definition, a community solar installation is a common-pool resource in that it has a capacity that cannot be exceeded and whose consumption of a certain amount of capacity limits another's consumption of it, while the installation has low barriers to enter into using said capacity. When such a common-pool resource is managed and designed by its stakeholders, however, there must be a system in place in which the stakeholders are brought together repeatedly in its design and management while also being held to a standard via a sanctioning capability of said system. Without such design, Ostrom writes that there stands the chance of a Tragedy of the Commons, in which the resource is depleted and appropriated to the extent that the system managing it is unsustainable. [17], [21] This process is depicted in Figure 5 below.

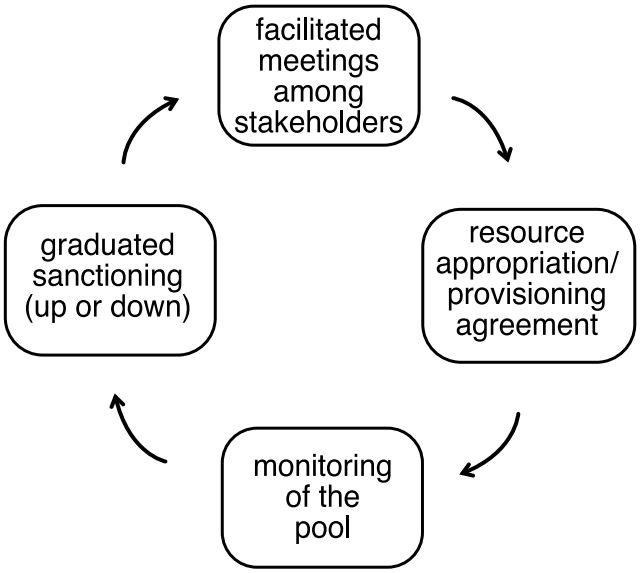

Figure 5: Ostrom's cycle of cooperative behavior through repeated events. This cycle of meeting, provisioning, monitoring, and sanctioning allows for the sustainable operation of a common-pool resource. [4], [17], [21]

Such behavior of the system is called cooperative behavior, and operates in a cycle of meeting with third party facilitation, agreeing on principles and acting upon the meetings, monitoring the resource, and sanctioning either up or down those stakeholders who acted for or against preconceived group intentions. [21] This sanctioning is key for the repeated intra-actions of

stakeholders taking place to stay on course, while it also allows for a facilitator to mold trust and reciprocity among participants through facilitated, repeated meetings. Without any sanctioning, a gathering of stakeholders is much akin to public forums, which, even though come in repeated communication settings, produce little result in the way of progress towards a goal – it is a free-for-all space. The cooperative behavior comes from a system's sanctioning capacity because there are checks on stakeholders and either advancements or restrictions on those who guide or misdirect the repeated communications, respectively. Figure 6 below depicts the characteristics of systems with varying levels of repeated communications and graduated sanctioning.

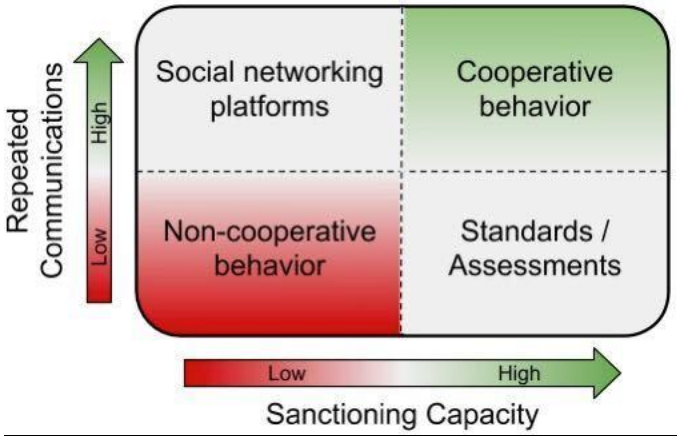

Figure 6: "Management critters". With repeated communication and graduated sanctioning, cooperative behavior can emerge from a system, but without both, can fall to the likes of social networking (low sanctioning) or government standards (low communication). [4], [21]

In the management of a system, facilitated communications must occur among stakeholders (who have differing beliefs, values, and principles) for goals to be reached. Ostrom shows, empirically, that increased communication via repetitive engagement allows for the greater achievement of those involved over their individual efforts without such communication. [3] Trust and reciprocity between stakeholders is built over repeated games, the result of which is connection between otherwise separate community members. From those connections, goals, problem-solving

methods, et cetera can be more deeply rooted in the group of stakeholders because of their endogenous nature that accounts for the different perspectives of those involved.

Chapter 3

Solar Policy Change and Methodology

1. Catalyzing Community Solar

Ferster et al. found that the groundwork laid by Ostrom in the cooperative game theory field held true in a real-world setting, finding, empirically, that the use of repeated, facilitated games (workshops as intra-actions amongst participants and those represented) between stakeholders paved the way for two separate megawatt-scale solar arrays to be approved with relative quickness. [4] Ferster et al. studied the Community Solar on State (CSOS) workshops that used integrative design to gather and align stakeholders in pursuit of an endogenously and jointly designed community solar installment. [4] The workshops, as intra-actions to (re)configure boundaries of beliefs, values, and principles towards alignment of joint intention, were repeated four times and facilitated with sanctioning power given to a third-party facilitator. [4] The CSOS framework followed Ostrom's repeated games design, which allowed for a provisioned commons to materialize from cycles of communication, allocation, management, and sanctioning. Trust and reciprocity were key to bringing these stakeholders together to build towards a common and endogenous goal. The workshops expedited solar installations in the community (one for the area joint authority for a water treatment plant, the other under the university's plant management for campus energizing) faster than either of those groups were doing before the workshops. Both parties had been looking into solar for years before then, but acknowledged that neither were prepared for the installation of the arrays in the timeframe guided by the workshops. The uninfluenced result is depicted in Figure 7 below.

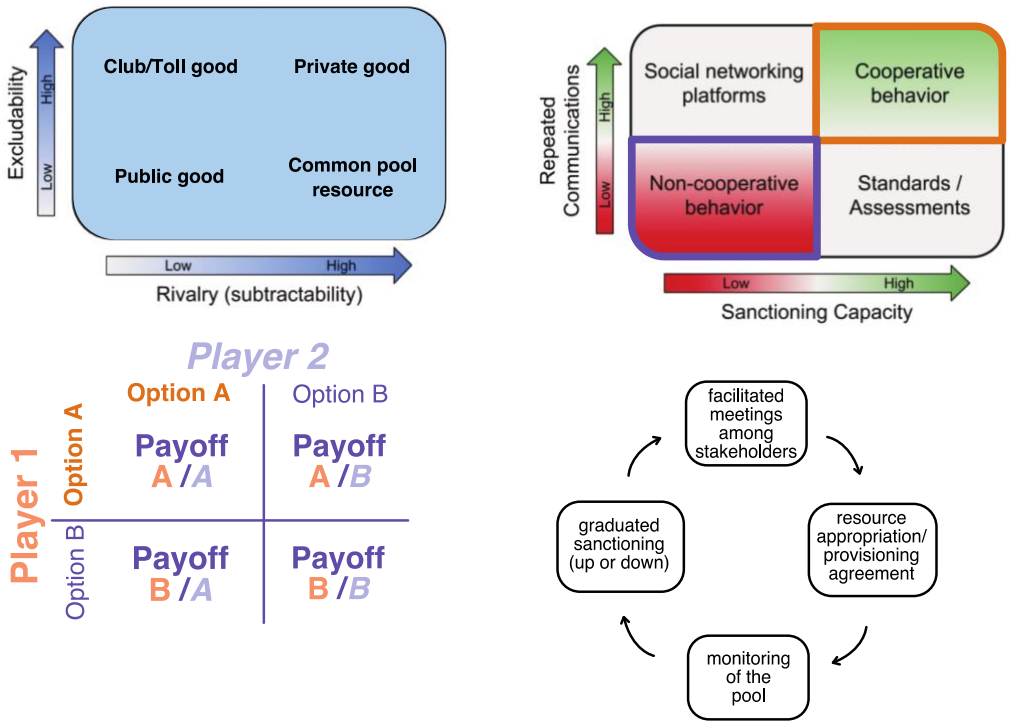

Figure 7: Integrated common-pool resource framework. This figure shows the connection between the models of common-pool resources and others goods, management critters, cooperative behavior cycles, and basic game theory. [4]

Without the ability to sanction stakeholders in a repeated communication setting, the system devolves into a non-cooperative game setting, usually resulting in a lesser result than that found through cooperation. However, in such a setting of cooperative engagements, a catalysis of goals can be materialized by the facilitation at hand, where catalysis is used to describe the facilitation's speeding up of the achievement of goals without taking ownership of it. Ferster et al. found, empirically, that such a facilitated and repeated engagement of stakeholders catalyzed the process of solar adoption by select involved stakeholders. [4] The approach of bringing the community and its stakeholders together along with those interested in installing those arrays allowed for increasingly connected projects to materialize. It is this overarching framework that has been used for solar policy and that has been shown to increase a policy's meaning and effectiveness towards those it affects.

2. Finding Pennsylvania's Solar Future

Finding Pennsylvania's Solar Future was a series of workshops, webinars, and discussions that spanned 30 months from 2017 through 2019. Its overall goal was to come up with Pennsylvania's Solar Future (PASF), a plan laying out the strategies required to get the state up to a 10% solar carve-out by 2030. [10] The project came about from the granting of a Solar Energy Evolution and Diffusion Studies 2 – State Energy Strategies (SEEDS2-SES) grant from the Department of Energy given to the Pennsylvania Department of Environmental Protection. [10], [23] The entire project was based off of a similar study conducted in Vermont called the Vermont Solar Pathways project and was pitched to several PA solar experts to gain an insight into the state's solar landscape. [24], [25]

The meetings, of which there were eight in person around the state with interspersed topic webinars, aimed to bring nearly all involved stakeholders in the solar policy realm together. In this way, the repeated nature of the meetings would bring about the discovery of the collected group's underlying interests and concerns through the building of trust between otherwise disparate stakeholders. Over 500 Pennsylvania solar stakeholders, representing groups ranging from powerful utilities to interested municipalities, actively took part in the meetings. [10] The expansive knowledge of those involved allowed for technical or industry know-how to aid in the production of the plan that would have otherwise been kept separated from or never discussed at length with one another without the trust built over time at said meetings. In this way, the workshops were managed by the conglomeration of the aforementioned background in order to ensure effective management, stakeholder-rooted endogenous goals, and cooperation between said stakeholders. The final plan was heavily based on modeling to be able to account for nearly all discussed topics of interest during meetings. It underlines the economic, health, and environmental

benefits of such a plan, with 15 key strategies to be followed if the 10% carve-out was to be decided upon by the Pennsylvania government. [9]

4. Act 40

Act 40 is a far-reaching appropriation amendment that was signed into law on October 30, 2017 that dealt with the Pennsylvania state budget and future budget implementation. Section 2804 of Act 40 specified an amendment to the Alternative Energy Portfolio Standards (AEPS) Act of 2004. It stated that in order to qualify for the accreditation as a source of renewable energy to produce electricity and, subsequently, Alternative Energy Credits (AECS) towards the solar photovoltaic requirements of the AEPS Act, that the solar facility must be located within the state's borders. [26] The intentions of the amendment to the AEPS Act were to combat an oversaturation of the Pennsylvania state market for AECs with out-of-state credits. This limitation was introduced to incentivize the production of solar power within the state, thus leading to the successful achievement of the original AEPS Act goal of 0.25% of total electric production coming from solar. With closed energy credit borders, increased requirements of solar electricity generation could be more easily proposed, implemented, and achieved. This would encourage Pennsylvanians to produce and plan for solar at rates seen in neighboring northeastern states such as Maryland and New Jersey. [9] Back in the earlier half of 2017, closing the AEC border was one of the first strategies proposed by Finding Pennsylvania's Solar Future to be able to reach a 10% carve-out of solar generation in the state. This aligns with the timeframe during which the amendment was being introduced and proposed at much higher rates since its introduction in 2011 by Republican Representative L. Chris Ross. [26]

Chapter 4

Comparative Investigation and Synthesis

1. Intra-action within PASF Phenomenon

The phenomenon of policymaking, trust-building, and direct and indirect relations (the Finding Pennsylvania's Solar Future project) included representatives of five entangled group agents involved in Pennsylvania solar power: utility companies, lobbyists and legislators, general stakeholders (public and private), organizers and facilitators, and the *facilitation* of all four of these groups as one. The collective of group agents (re)configured boundaries of joint intention around beliefs, values, and principles within their composite system to practice joint intention as a cooperative group agent, allowing for the design and management of their system to be made easier with great leverage for change aimed in the correct places. As a single group agent, Finding PASF was able to collectively determine what mattered and made indeterminate what was excluded from mattering to Pennsylvania solar.

As a new and entangled group in the overall phenomenon, this group agency of facilitation runs parallel to Ferster et al.'s findings of the greater facilitation of involved group agents intra-acting to become one whole agent. [4] The facilitative setups of both processes were also the same, as they involved Dr. Frey Brownson as the one of the facilitative heads to ensure intra-action with correct graduated sanctioning and repeated events. [4], [10] This correspondence of key aspects of both processes allows for the theoretical, yet not empirical, background necessary to claim that Finding PASF catalyzed Section 2804's passing.

With newly defined boundaries pertaining to all involved in the collective group agent, effective system design (i.e., policymaking) was enabled, and the collective's ability to act as a

whole expanded. The emphasis to become effective as a policymaking group highlights a core tenant of the process: it need not be efficient. Taking 30 months to suggest a plan of action for the increase of solar installation in the state is nowhere near efficient – legislators with the right powers may be able to cut many months off of such a process if applied correctly. The emphasis of Finding PASF was that the discourse included all involved among solar in the state, with intentions of deeply rooting the collective goals and designs among stakeholders across Pennsylvania. In this way, planning across the board at many levels of power can be more effective at tackling current challenges of policymaking, as well as establishing methods to do so in the future. This is a result of effective design and the power to shift the paradigm of mess management, which was the result of intra-action and the (re)configuring of boundaries enfolded within the phenomenon of Pennsylvania solar.

As a cohesive and effectively designed phenomenon, Finding PASF was able to more clearly have effects on the process of passing solar legislation in the state. The policies, while phenomenon that were intra-acting before the Finding PASF process began, were catalyzed by the repeated series of workshops and intra-actions due to their effective design and facilitation.

2. Nonlinear Effect Materialized in Act 40

With the language found in Section 2804 first mentioned in a proposed bill in 2011 and the passage of Act 40 in late 2017 during the course of the Finding Pennsylvania's Solar Future project, it is surmised that the repeated facilitative workshops catalyzed the passage of Section 2804, closing the state's solar alternative energy credit border. Between 2011 and 2017, there were 11 separate proposals for closing the AEC border as an amendment to the original AEPS Act of 2004. The

concentration of those proposals center around the 2016-2017 timeframe, with the highest number of proposals in a single year, four, coming in 2017. [12] It cannot be said that there was a linear causation of the closure of the AEC border due to the Finding PASF process, but a cooperative effect from the repeated events can be observed enough by the overall section's timeline. Section 2804 is a relatively small piece of legislation that did not require sweeping reform to be enacted, but its inclusion into Act 40 during the process of review during 2017 can be nonlinearly attributed to the high value endogenously placed upon it by the PASF system. Little cooperative work was done on passing the section's language from 2011 to 2016, but Finding PASF allowed group agents, some of which involved lobbyists and policymakers, across the entire state to (re)configure what mattered to solar power in Pennsylvania.

Chapter 5

Conclusion

Systems management and an agential realist approach employing intra-active language were synthesized into an overarching framework of design called “intra-active planning”. This synthesis of vernacular describes the means through which the management of a system, when commenced, occurs by managers who cannot, by definition, be isolated from said system. This framework was defined as a means to make the planning of systems explored by Ackoff more meaningful and effective with the use of Baradian language. Finding Pennsylvania’s Solar Future was studied as a possible catalyst to the closing of the state’s solar energy credit border with comparison made between the framework and that of Community Solar on State for empirical support. Against a background of agential realism, systems management, facilitation, and cooperative action catalysis, this paper has presented the Finding PASF framework as having effectively catalyzed the passage of Section 2804 in Act 40 that closed Pennsylvania’s solar AEC borders through extensive involvement of stakeholders across the state. The PASF project, and subsequent plan, were endogenously determined via intra-action between the group agents involved in the process, allowing for an effective plan to result and a system design that enables joint action across myriad stakeholders. With the catalysis of Section 2804, additional research could be conducted into the passage of policy allowing community solar in Pennsylvania as the subject was a key topic in the final PASF plan and because the idea of community solar has been present in the state for several years without action. This investigation could be based on the synthesis of the work of Ferster et al., incorporating systems thinking and design into the framework of intra-action and the (re)configuration of boundaries amongst a system. Such a framework has potential not only in

solar policy establishment, but management as a whole, as it may apply to the management of corporations, resources (e.g. community solar), and group agents emergent from phenomena.

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EDUCATION

The Pennsylvania State University *Schreyer Honors College Class of 2020* **University Park, PA**
College of Earth and Mineral Sciences, B.S. in Energy Engineering,
B.S. in Energy Business and Finance

WORK EXPERIENCE

Sun Directed **State College, PA**
Business Development Intern *May 2018 – August 2018*

- Formatted company's commercial and residential customer proposal documents
- Analyzed commercial clientele market trends for solar sales advantages
- Modeled simple solar systems for base-level cost and production estimations
- Researched and tested improvements for ground mount system installations

Dr. Jeffrey Brownson Solar Group **University Park, PA**
Solar Power Research Assistant – Photovoltaics (PV), Solar Ecology Focuses *January 2017 – May 2020*

- United PV and agriculture to study revenue variability in PV installments
- Connected System Advisor Model with PSU Agricultural software using Python
- Studied ecological impact varied levels of solar designation have on farm output
- Focused on PV penetration across multiple disciplines to ensure sustainability

Penn State id+ Office **University Park, PA**
Student Summer Worker *May 2016 – August 2016*

- Outlined Penn State's Lioncash and ID systems to incoming Freshmen
- Assisted in the orientation of families new to Penn State student financial systems

LEADERSHIP & ACTIVITIES

Society of Energy Engineers (SEE) – Member **University Park, PA**

- Connected with Energy Engineers through professional opportunities *August 2017 – May 2020*
- Learned about possibilities in Energy Eng. and Energy Business and Finance

College of Engineering – Engineering Orientation Network (EON) – Mentor **University Park, PA**

- Led a team of Engineering Freshmen during their college orientation *August 2017*
- Acted as a guide for the students by introducing resources and answering questions

American Solar Energy Society (ASES) – Member, 2017-18 Treasurer **University Park, PA**

- Co-organized 2017 Solar Tour, highlighting local solar installments *April 2017 – May 2020*
- Tracked club finances by collecting dues and overseeing project component orders
- Discussed achievable financial goals for projects with officers and members

Engineers for a Sustainable World (ESW) – 2018-19 VP, 2017-18 Secretary **University Park, PA**

- Communicated with general body pertaining to club events and meetings *October 2015 – May 2020*
- Maintained strategic updates between club officers to produce email announcements
- Offered points of input and assistance to various officers for the good of the club

Penn State IFC/Panhellenic Dance Marathon (THON) **University Park, PA**
***Springfield FTK** – 2016-17, 17-18, 18-19 Class Representative, Member* *April 2016 – May 2020*

- Contributed to the largest student-run philanthropy that raised $10 million in 2018
- Organized class events to boost camaraderie and involvement within club
- Relayed important information from executive board to fellow classmates

SKILLS

Proficient in Energy Toolbase, Microsoft Office suite, Python, SAM; intermediate in MATLAB